European Spongy moth (*Lymantria dispar*) (Lepidoptera) outbreaks in some regions of European Russia in 2023

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Abstract. A study was conducted to investigate the distribution and significant increase in the abundance of *Lymantria dispar* within the forest-steppe zone of European Russia, encompassing the regions of Ryazan, Moscow, Vladimir, and Ulyanovsk. The examination of hotspots associated with this pest during the year 2023 involved an analysis of data derived from diverse sources. The investigation encompassed an assessment of plant species that either attracted or repelled the pest's caterpillars under natural conditions. The defoliation phenomenon was observed to vary across distinct plant species, with notable instances of extensive destruction identified on *Betula, Quercus robur, Populus tremula*, and various *Salix* species at multiple observation plots. Conversely, conifers such as *Larix sibirica, Picea abies, Pinus sylvestris,* and certain invasive (introduced) species, including *Acer negundo, Elaeagnus argentea, Hirrarchaea rhamnoides,* and *Syringa vulgaris*, exhibited an absence of caterpillar presence.

1 Introduction

In recent decades, a confluence of factors, including climate change, increased anthropogenic activities, urbanization, and catastrophic events such as fires, droughts, and floods, alongside the proliferation of invasive species, has caused notable changes in the processes of natural ecosystems [1–8]. These transformative processes disrupt historically balanced undisturbed ecosystems, leading to a perturbation in ecological equilibrium conducive to the proliferation of pests and a subsequent surge in their populations. The resultant sporadic outbreaks of insect pests pose a formidable challenge to forest health on a global scale, engendering significant loss of ecological resources and contributing to ecosystem degradation. Causative factors underpinning these outbreaks encompass meteorological conditions such as temperature and humidity variations, a decline in the populations of natural predators, and the potential for pests to traverse extensive distances [9–11].

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The European Spongy Moth (*Lymantria dispar* (Linnaeus, 1758)) represents one of the most pervasive and deleterious forest pests across Eurasia, North America, and several African nations. Functioning as a formidable defoliator, it poses a significant threat to mixed and broadleaved forests on these continents [12–14]. The voracious appetite of European Spongy Moth extends to approximately six hundred plant species, thereby inflicting considerable damage to forestry [15].

A noteworthy instance of this impact unfolded post-1993, wherein a four-year monitoring initiative was undertaken along the gradual spread front of the European Spongy Moth in the coastal plain of Maryland and Virginia, USA. The examination revealed heightened defoliation intensity on susceptible oak and oregano species. Subsequent to defoliation events, a notable increase in tree mortality, measuring 4.4 m²/ha, was observed in pine-oak forests. Pine mortality predominantly affected diseased and young trees, underscoring the nuanced ecological consequences of European Spongy Moth infestations [13].

The population density of *Lymantria dispar* in communities typically remains low. However, for various reasons, it can undergo rapid escalation, eventually attaining the status of a pest. The duration of interlude periods between outbreaks is presumed to be associated with climate conditions, being shorter in dry forests and longer in humid ones. Nevertheless, other potential causes for outbreaks of this pest cannot be ruled out [16, 17]. The objective of this study was to elucidate the outbreak dynamics of *Lymantria dispar* in select regions of European Russia during the years 2022 and 2023.

2 Materials and methods

The data for this study were gathered within the Ryazan, Moscow, Vladimir, and Ulyanovsk regions of European Russia during the year 2023. Several districts within the aforementioned regions underwent comprehensive scrutiny. Furthermore, Additionally, information regarding the hotspots of European Spongy Moth spread was examined from various sources in the Republic of Tatarstan, Ulyanovsk, Samara, and Vladimir regions.

To assess foliage destruction across various plant species, a visual scale was devised to rank the degree of leaf consumption on individual trees or shrubs: "–" denoting untouched foliage; "+" indicating a minor proportion (less than 5%) of leaves consumed; "++" signifying the obliteration of half of the foliage on a given tree or shrub; "+++" representing the destruction of over 80% of foliage on an individual tree or shrub. In total, more than 700 specimens of trees and shrubs, spanning various species, were subjected to meticulous visual observations, with herbaceous plants being excluded from consideration. Special emphasis was directed towards invasive plant species.

3 Results

In the year 2023, we observed the active reproduction and substantial prevalence of the European Spongy Moth across four regions: Ryazan, Moscow, Vladimir (Central Russia), and Ulyanovsk (Figure 1). In addition, noteworthy foci of tree infestation by European Spongy Moth caterpillars were identified within the territories of Ulyanovsk, Samara regions, and the Republic of Tatarstan. Thus, within the central belt of the European part of Russia in 2023, there existed a minimum of two significant proliferation foci, affecting at least six regions. One hotspot was situated in Central Russia, while the second was active in the Volga region.

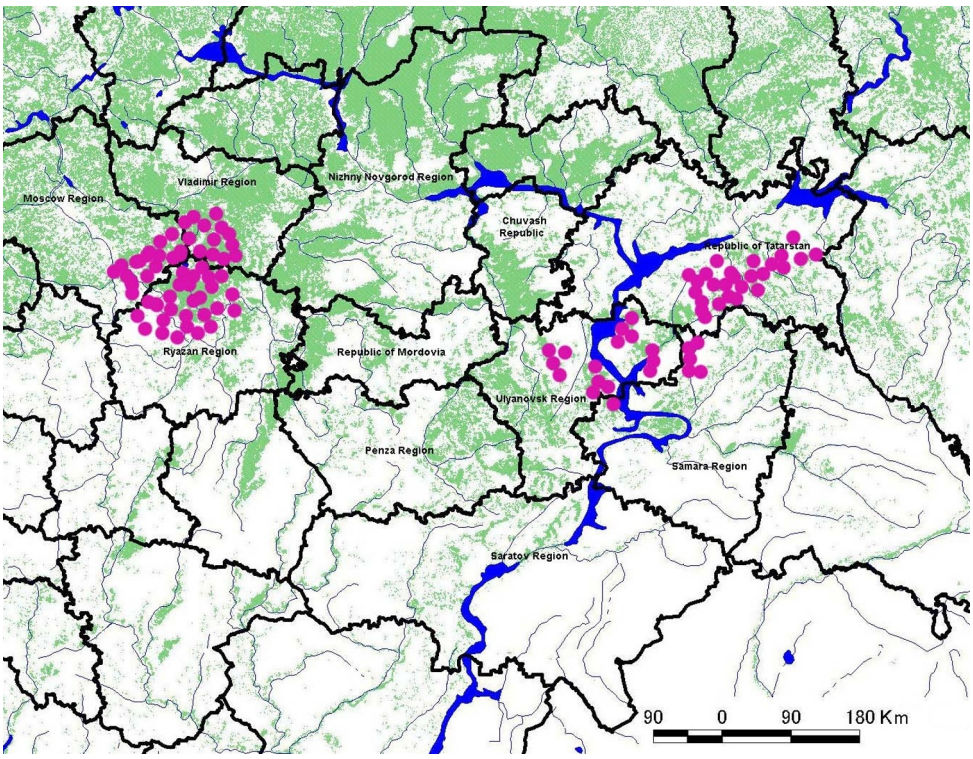

Fig. 1. The map of recorded active foci of European Spongy moth distribution in 2023 (indicated with pink dots).

Active reproductive foci of the European Spongy Moth were observed across various regions, specifically in the Moscow region (Shatury, Egoryevsk, and Lukhovitsy districts), Ryazan region (Klepiki, Rybnoe, Ryazan, Spassky, Kasimov, Shilovo, Pitelino districts), Vladimir region (Sobinka, Petushki, Gus-Khrustalny, Melenki districts), Ulyanovsk Region (Novomalyklinsky, Cherdakly, Maina, Sengilei districts), Samara Region (Elkhovka, Koshkino, Stavropolsky districts), and the Republic of Tatarstan (Alekseevsky, Nurlat, Aznakaevo, Aksubaevo, Alkeevsky, Almetyevsk, Sarmanovo districts).

A total of at least 14 tree and shrub species were identified as hosts for European Spongy Moth. Foliage destruction was documented at varying degrees on different plant species. For instance, birch, oak, aspen, and various willow species were nearly completely decimated in several locations, leaving trees bare of leaves (Figures 2 and 3). This phenomenon was particularly pronounced in roadside forest areas, where, along roads in Ryazan and Moscow oblasts, nearly all trees reached the defoliation stage.

Notably, caterpillar presence was absent on seven identified species, predominantly comprising coniferous trees (*Larix sibirica, Picea abies, Pinus sylvestris*), as well as invasive (introduced) species (*Acer negundo, Elaeagnus argentea, Hippophaë rhamnoides, Syringa vulgaris*) (Table 1).

Table 1. List of tree and shrub species with observed foliage loss, by region.

Species	Region	Foliage destruction rank
Native		
Hippophaë rhamnoides L.*	Ryazan	–
Picea abies L.	Moscow, Vladimir	–
Pinus sylvestris L.	Ryazan, Moscow, Vladimir	–
Alnus sp.	Ryazan, Moscow, Vladimir, Ulyanovsk	+
Corylus avellana L.	Ryazan, Moscow, Vladimir, Ulyanovsk	++
Euonymus verrucosa Scop.	Ryazan, Moscow, Ulyanovsk	++
Frangula alnus Mill.	Ryazan, Moscow	++
Lonicera xylosteum L.	Ryazan, Moscow, Vladimir, Ulyanovsk	++
Sorbus aucuparia L.	Ryazan, Moscow, Vladimir	++
Tilia cordata Mill.	Ryazan, Moscow	++
Acer platanoides L.	Ryazan, Moscow, Ulyanovsk	+++
Betula sp.	Ryazan, Moscow, Vladimir, Ulyanovsk	+++
Malus domestica Borkh.*	Ryazan, Vladimir, Ulyanovsk	+++
Populus tremula L.	Ryazan, Moscow, Vladimir, Ulyanovsk	+++
Quercus robur L.	Ryazan, Moscow, Vladimir, Ulyanovsk	+++
Salix sp.	Ryazan, Moscow, Vladimir	+++
Invasive		
Acer negundo L.*	Ryazan, Moscow	–
Elaeagnus argentea Pursh.*	Ryazan, Vladimir	–
Larix sibirica Ldb.*	Ryazan	–
Syringa vulgaris L.*	Ryazan, Moscow, Vladimir	–
*Populus alba L.**	Ryazan, Moscow	++

* - species planted by humans and not previously found in natural ecosystems.

Fig. 2. Condition of wind-protective roadside forest plantations of young birch trees (Ryazan region). Leaves completely destroyed by European Spongy Moth are clearly noticeable. Above right, there is a picture of European Spongy Moth on an aspen leaf (photo by A.B. Ruchin).

a b c

Fig. 3. Damage of different plants by European Spongy moth caterpillars: a - Malus domestica; b - Aseg platanoides; c - forest with aspen and birch (photo by E.A. Lobachev and A.B. Ruchin).

Particularly vigorous foliage destruction was observed on the following plant species: *Acer platanoides, Betula sp., Malus domestica, Populus tremula, Quercus robur, Salix sp.* According to our observations, European Spongy Moth primarily consume foliage on *Betula sp.,* followed by *Quercus robur and Salix sp. Subsequently*. Further, they initiate foliage consumption on other trees and shrubs.

4 Discussion

Lymantria dispar is a perennial species characterized by four discernible life stages: egg, larva (caterpillar), pupa, and adult [17]. In the year 2022, aggregations of *Lymantria dispar* manifested in various urban and regional settings across European Russia, exhibiting oviposition behavior on diverse surfaces such as building exteriors, streetlights, fences, gardens, and parks. The initial infestations of this pest were noted in the Ryazan, Vladimir, Moscow, and Ulyanovsk regions [18]. A salient attribute of the European Spongy Moth is the persistent proclivity of its populations toward extensive reproductive activity. In natural ecosystems, under typical conditions, the population density of *Lymantria dispar* does not stabilize at a basal threshold and scarcely approaches an equilibrium point; instead, it promptly initiates an upward trajectory [19].

The distribution of *Lymantria dispar* within new territories, characterized by a substantial increase in population density, is primarily facilitated by the dispersal of larvae over short distances. Furthermore, there is recurrent evidence indicating that human activities may inadvertently create conditions conducive to the long-range movement of this pest [20]. The distribution of caterpillars is achieved through swift terrestrial locomotion from one tree to another or via the aerial movement of larvae employing silk threads they secrete [21]. It is not precluded that unintentional transportation of European Spongy Moth larvae may occur through motorized vehicles, as larvae have been frequently observed within cars. This phenomenon potentially explains the noteworthy damage observed in forests adjacent to roadways, juxtaposed with the comparatively less pronounced foliage damage in arboreal specimens situated deeper within the forest.

The active predation exerted by large beetles, specifically Carybidae, emerges as a plausible factor impeding the proliferation of the *Lymantria dispar* population. Carybids, recognized as significant predators of Lepidoptera in woodland ecosystems, have the potential to play a pivotal role in the regulation of moth pests [22]. Notably, our observations during the period of caterpillar mass distribution and defoliation peak on June

10, 2023, in various biotopes within the Ulyanovsk region revealed heightened activity of *Calosoma sycophanta* beetles during daytime hours. Along a designated route with a width of approximately 1.5 meters, traversing a clearing in broad-leaved and birch forests, the recorded density of *Calosoma sycophanta* individuals was 10 per 1.47 kilometres. It is noteworthy that during the remaining months of the collections (May, July, August, September, October), no beetles were observed along this route. *Calosoma sycophanta* is documented as a predator of the European Spongy Moth, and its activity exhibits a marked increase when prey abundance is high [23].

The larvae of the European Spongy Moth exhibit a broad dietary spectrum, consuming a diverse array of plant species. In Europe, their feeding preferences vary regionally, encompassing species such as *Alnus, Prunus, Quercus, Gleditsia, Tilia, Carpinus, Populus, Corylus,* and *Robinia* [24]. Notably, in southern France, *Lymantria dispar* exhibit a predilection for various *Quercus* species, while in Romania, a higher incidence of larval feeding occurs on *Populus* and *Salix*. In Lithuania, their preference extends to *Betula* and *Alnus* trees [25]. Consequently, the vegetation types favored by the European Spongy Moth larvae diverge across regions. Nevertheless, a consistent observation is that in instances where leaves on the "preferred" trees and shrubs are depleted, the caterpillars adapt by consuming leaves from alternative vegetation types. Substantiating this phenomenon, we documented complete foliage destruction of oaks in the Ulyanovsk region, accompanied by significantly lesser foliage damage on *Acer platanoides*. Similarly, in the Ryazan region, when Betula foliage was entirely consumed, the larvae transitioned to feeding on the foliage of *Populus tremula*, *Quercus robur, Salix*, and subsequently on other tree and shrub species, such as *Tilia cordata* and *Alnus*.

In the Ryazan, Vladimir, and Moscow Regions, the presence of European Spongy Moth was not documented on coniferous trees. Conversely, oral reports from the Republic of Tatarstan indicated significant damage to *Pinus sylvestris*, especially young specimens, caused by larvae of the moth, with instances of complete defoliation. According to some sources [13], the European Spongy Moth can inflict extensive damage to needles in young *Pinus sylvestris* trees, ultimately resulting in their demise. Another coniferous species, *Picea abies*, is considered secondary in the context of large *Lymantria dispar* outbreaks. It is believed that the pest resorts to feeding on needles only when primary host trees are nearing complete depletion [26]. *Larix sibirica*, while suitable for supporting caterpillar feeding in its natural habitats [27], is more commonly utilized for windbreaks along highways and fields in the forest-steppe of the European part of Russia. Its non-native status renders it less attractive to European Spongy Moth in these regions.

Furthermore, the intriguing aspect of the larvae's avoidance of certain invasive tree species, except for *Populus alba*, merits attention. Shields et al. [28] conducted a study on the feeding preferences of *Lymantria dispar* larvae in North America, revealing that *Liquidambar styraciflua* and *Quercus rubra* were highly consumed, while *Fagus grandifolia* and *Juglans nigra* were less preferred. *Liriodendron tulipifera* was consistently rejected. Additional findings indicated a preference for *Quercus rubra*, *Populus grandidentata*, *Ostrya virginiana, Amelanchier spp.,* and *Acer saccharum,* with less interest in species such as *Prunus serotina, Betula lutea, Acer rubrum, Acer pensylvanicum*, *Fraxinus americana,* and *Ulmus rubra* [29]. Some reports suggest a reluctance of European Spongy Moth to consume leaves of *Acer negundo* [30]. Unfortunately, literature lacks specific data on the larvae's feeding behavior regarding *Elaeagnus argentea, Hippophae rhamnoides,* and *Syringa vulgaris*.

5 Conclusion

The study centered on the distribution and outbreaks of *Lymantria dispar* in the forest-steppe zone of European Russia, encompassing the Ryazan, Moscow, Vladimir, and Ulyanovsk regions. Diverse sources were scrutinized to analyze the hotspots of this pest in 2023. Active reproduction foci of the European Spongy Moth were discerned in the Moscow Region (3 districts), Ryazan Region (7 districts), Vladimir Region (4 districts), Ulyanovsk Region (4 districts), Samara Region (3 districts), and the Republic of Tatarstan (7 districts). Among the trees and shrubs susceptible to European Spongy Moth feeding, a minimum of 14 species were identified. Varied proportions of foliage destruction were documented across different plant species. Notably, *Betula, Quercus robur, Populus tremula,* and various *Salix* species exhibited near-complete defoliation at specific plots. Conversely, there no caterpillars observed on conifers (*Larix sibirica, Picea abies, Pinus sylvestris*) and invasive (introduced) species (*Acer negundo, Elaeagnus argentea, Hirrarchaea rhamnoides, Syringa vulgaris*). These findings corroborate and refine previous reports regarding the dietary preferences of *Lymantria dispar* in both North America and Eurasia.

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